Attachment 1. Survey of Bohena Creek riparian plant communities

Report for *Upper Mooki Landcare Inc*

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Summary

The riparan vegetation bordering Bohena Creek was surveyed to describe its plant community type, diversity, structure and condition. The following are the main findings of this survey:

- The plant community along the banks of Bohena Creek is typically a grassy woodland, dominated by Blakely's Red Gum, Rough-barked Apple and White Cypess Pine. Other species such as Yellow Box and Kurrajong also occur less frequently in the canopy.
- The Plant Community Type which best fits this community is PCT544 *Rough-barked Apple - White Cypress Pine - Blakely's Red Gum riparian open forest / woodland of the Nandewar Bioregion and New England Tableland Bioregion* due to the similarity in species composition and topographical position.
- PCT 399 *Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion* was encountered within the creekbed environment at two sites.
- PCT401 *Rough-barked Apple – Red Gum - Cypress Pine woodland on sandy flats, mainly in the Pilliga region* was detected once, showing very little difference with the more frequently encountered red gum community, apart from the presence of Baradine Red Gum.
- PCT408 *Dirty Gum (Baradine Gum) – Black Cypress Pine – White Bloodwood shrubby woodland* was found at one creekside site due to some outcropping sandstone.
- Based on the similarity with characteristic species listed in the scientific determination for *White Box Blakely's Red Gum Yellow Box Woodland,* the community identified here as PCT544 shhows a high level of correspondence.
- Due to the variation on site condition, eight of the sites would meet the criteria for the Commonwealth-listed *White Box Blakely's Red Gum Yellow Box Woodland and Derived Native Grassland*.
- One site and one transect in particular (4.2) was found to be in poor condition, with high levels of dead trees, weed cover and low plant diversity.

Background

Bohena Creek is a 5th order stream and the most important stream in the eastern Pilliga, feeding into the Namoi River 9 km north-west of Narrabri at the junction with Namoi Creek. In the upper reaches, the Bohena splits into two creeks within the Pilliga East State Conservation Area, the Borah and Yaminbah Creeks whose source is south of the Pilliga. In all, this catchment covers some 100km in length.

While regarded as an intermittent creek, Bohena is capable of discharging huge surface flows following times of good rain into the Namoi. In addition, this is aided by a perched aquifer which supports both riparian communities and groundwater dependence but also assists in rapid discharge of surface flow.

Bohena Creek flows north through the middle of the proposed Narrabri Gas production field and so it is important to understand the significance of this major stream both at a local and regional scale.

In the light of the recent submission of the EIS for the Narrabri Gas Project, this study attempts to verify the types riparian plant communities along Bohena Creek, to describe their condition, structure and composition.

Methodology

Site selection

Site selection was predominately governed by two main factor:

1. Proximity to creek. All transects were to be conducted as close as possible to the creekside evironment.
2. Access ease. All sites were located within 200m of access roads, primarily Creaghs Road, Bohena Creek Road and McCanns Road and the Newell Highway.
3. Sites were located as far as possible at a distance of 5km from each other. Some sites ended up further apart, some were closer due to logistical constraints.

In all, eight 'sites' were selected, each with two vegetation survey transects and one creekbed assessment area. The sites are depicted in Figure 1.

Figure 1. Location of study sites

Site surveys

Figure 2 shows the site layout with survey transects and quadrats. Two plots were loacted at each site of the creek, along with a cental creekbed assessment area. Vegetation surveys were carried out using the methdology as outlined in the Framework for Biodiversity Assessment (FBA) of a nested quadrat to survey diversity and a central transect line to survey cover. The following modifications were made to the methdology:

Figure 2. Layout of site surveys.

1. Transects were conducted over 100m in order to get a more detailed assessment on the number of dead standing trees and dominants in the different canopy layers above ground-level. All trees (>10cm dbh) were counted within an area 40m wide by 100m long (0.4 ha) and all overstorey and midstorey species were noted.
2. Cover estimates of the cover of the different vegetation strata and weeds were made across 20 points along the transect, each point 5 m apart. Where no 'hits' were recorded but plants in that layer or category were observed, this is recorded as <5%.
3. Creekbed assessments were undertaken within the 100m length of creekbed in lie with the vegetation transects. This involved a walk over of the area, noting common species and a visual estimate of cover for the different strata. 'Island' vegetation were excluded from this analysis as they we found to be inhabited by terrestrial vegetation, more resembling the creek terraces.

Results

Community type

The site data is presented in Appendix 1. Four communities within the VIS Plant Community Type database were identified in the transects surveyed. Two community types, PCT544 (n=13) and 401 (n=1) were found to have a woodland structure, matching the criteria of the Grassy Woodland Keith Formation. One site was found to support the shrubby woodland type PCT 408, matching the criteria of the Dry Sclerophyll Forest (shrubby) Formation. One transect (4.2) was found to be in such poor condition that assigning a community type was based on assumptions about its natural condition.

Figure 3. PCT 544 (Transect 1.2)

Figure 4. PCT401 (Transect 4.1)

Figure 5. PCT 408 (Transect 5.1)

Not counting 'islands' which were not sampled, only two creek-bed sites (S7 and S8) were found to support a vegetation community, most being too bare to qualify as plant communities. These sites match the criteria of the plant community type 399, another Dry Sclerophyll Forest (shrubby) formation, though also labelled as being a 'wetland' which matches the on-ground conditions at these sites.

Figure 6. Creekbed at Site 7 (PCT399)

Permanent or semi-permanent waterholes were also detected at sites S5, S7 and S8, which are surrounded by similar wetland vegetation described as being PCT 399, though were not surveyed.

Figure 6. Waterhole at Site 4.

Native Plant diversity

Not all species were identified so total diversity across the sites is somewhat higher than presented here. In total, 66 species were identified in the PCT complex 544/401, with the most diverse layer being groundstorey, forbs with 26 identified species, grasses contributing 12 species. Understorey was not particularly diverse with 14 species, midstorey and canopy with six and seven species respectively.

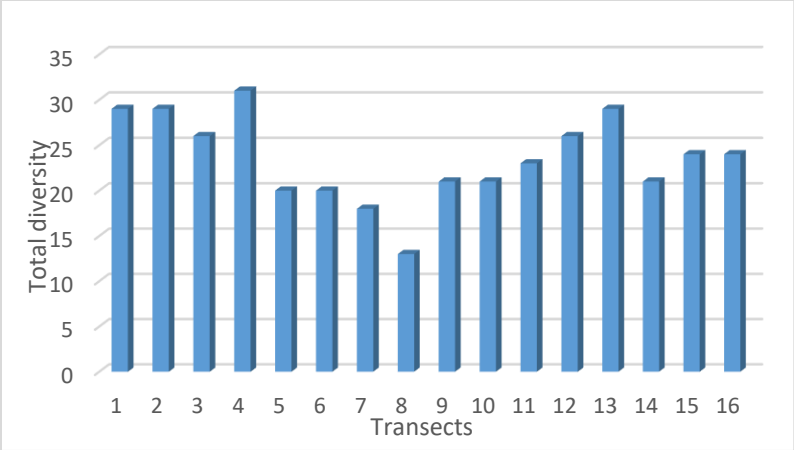

Figure 7. Native plant diversity across sites.

The lowest levels of diversity were found at transects 4.1 (#7) and 4.2 (#8) which also correlates with lower levels of 'condition' at these sites.

The most common overstorey species were Blakely's Red Gum, Rough-barked Apple and White Cypress Pine, occurring in different levels of dominance across the transects, though always present. Yellow Box was uncommonly encountered while Kurrajong and Bull Oak were encountered only once.

Mid-storey was usually dominated by one species, Dean's Wattle, though sometimes scattered tea tree and bottlebrush also occurred. These species were not present at most transects despite them being placed along the bank of the creek.

The understorey was generally dominated by two sedge species, Long-leaf Lomandra *Lomandra longifolia* and Rough Saw-sedge (*Gahnia aspera*) across most transects, along with the rushes *Juncus* sp and *Cyperus* sp. Xeric heaths and peas were generally scarce in the riparian zone examined, with the Darling Pea *Swainsona cadellii,* the most common of the Fabaceae in this layer.

Ground forbs were reasonably diverse, with ground-storeys commonly dominated by *Dichondra repens, Sida corrugata* and *Oxalis perrenans.* Grasses at the transects were most commonly the wire-grass *Aristida ramosa, Austrostipa setacea, Digitaria diffusa* and Weeping Grass *Microleana stipoides*. The exotic grass cover, couch *Cynodon dactylon,* was common.

One threatened species was detected, *Commersonia procumbens* at Transect 1.2.

Condition

Two measures of condition were analysed across the transects, numbers of dead standing trees and weed cover.

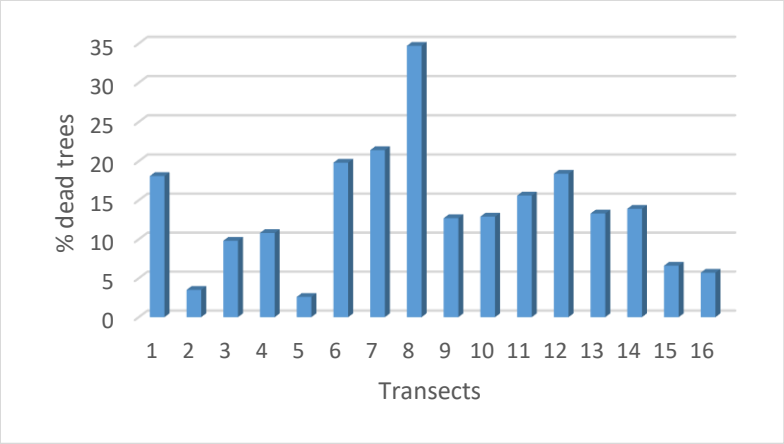

Figure 8. Proportion of dead standing trees as percentage of total standing stems across the transects.

Transect 4.2 has significantly more dead trees as a proportion of total standing stems than the other sites (with 34% of all standing stems being dead). Otherwise the normal level of standing dead trees lies between 2 and 20% of total standing stems in the rest of transects.

Where high numbers of dead trees were detected, resembling areas of dieback, it was found that the Blakely' Red Gum as the most affected. Transect 4.2 also contained a substantial number of trees suffering from dieback but which regeneration has occurred along the stems. These were counted as 'live' trees in this study.

Drone footage of the creek vegetation along Bohena Creek south of X-Line Road up to Brandon's Road intersection show distinct patches of red gum dieback in this part of the creek (Appendix 3).

Weed cover varied considerably at sites to between 5 and 50% cover within the groundstorey and understorey considered together. Consistent with the results concerning diversity and % dead trees, weed-cover was highest at the transects at site 4.

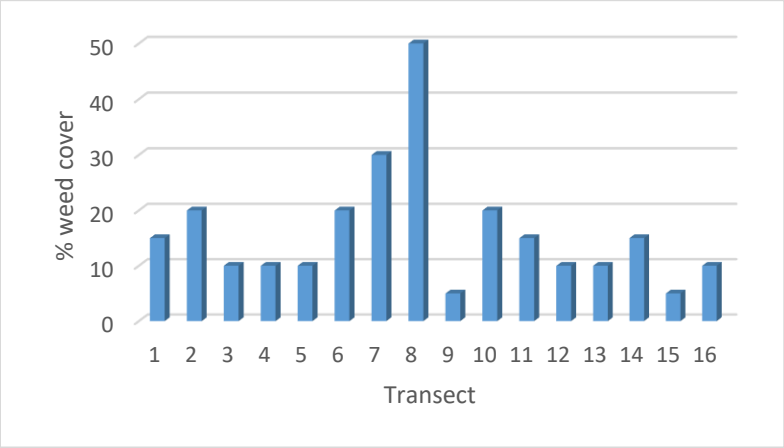

Figure 10. % weed cover across the transects

Nine weed species were commonly occurring at the survey sites, the species which account for most of the groundcover were Mayne's Curse *Glandularia aristigera*, Fleabane *Conzya bonariensis* and sometimes

Sticky Beak *Bidens pilosa*. Other commonly occurring species are *Cynodon dactylon, Sonchus oleaceus, Polycharpon tetraphyllum, Anagallis arvensis, Xanthium strumarium* and Prickly Pear *Opuntia stricta*.

Discussion

Community types

There was some variation in floristics and structure of the woodland communities within the study area, despite the targeting in the location of sites.

While most of the creek and riparian environment can be described as an alluvial environment, with creekbed and creek terraces on loam-sand soils, Pilliga Sandstone can abut the creekbed itself as was observed at one site. At transect 5.1, the geological boundary was noticeable on the eastern side of the creek, rising some three meters above the level of the creekbed. This area supported shrubby woodland.

One community was categorized as the PCT 401 due to the presence of Baradine Red Gum, *E. chloroclada,* though for the rest of the species within the community, it was not found to be measurably different from the more common type, identified here as PCT 544.

EcoLogical Australia (2016) have mapped several communities along Bohena creek, though categorise the dominant creekside community containing Blakely's Red Gum as being PCT399 *Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion*. From the Dry Sclerophyll (Shrubby) Forest and Western Slopes Dry Sclerophyll Forests Keith Class, the PCT description is as follows:

399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	Eucalyptus blakelyi , Eucalyptus camaldulensis <--> chloroclada , Angophora floribunda , Callitris glaucophylla / Leptospermum polygalifolium subsp. transmontanum , Acacia deanei subsp. paucijuga , Acacia penninervis var. penninervis , Callistemon linearis / Arundinella nepalensis , Juncus continuus , Cyperus lucidus , Alternanthera denticulata

This assignment cannot be supported for the following reasons:

(a) The riparian woodland in question was found generally to contain a low overstorey height of 10-20 m, an open understorey with relatively little mid-storey (0-30%) or understorey shrub cover (5-30% cover), a lack of sclerophyllous shrubs, and having a high litter cover with groundcover dominated by grasses and forb species. This would fall within the Keith formation as "Grassy Woodland', not "Dry sclerophyll (shrubby) forest".

(b) The species composition of this community was found to be more consistent with the grassy woodland type PCT ID544 *Rough-barked Apple - White Cypress Pine - Blakely's Red Gum riparian open forest / woodland of the Nandewar Bioregion and New England Tableland Bioregion*, as it always contained White Cypress Pine *Callitris glaucophylla* and sometimes Yellow Box *Eucalyptus melliodora* in the overstorey; a mid-storey dominated by the soft-leaved wattle *Acacia deanii* with only scattered sclerophyllous species, such as *Persoonia*; a low shrub cover mostly dominated by

Lomandra longifolia; sometimes aquatic plants are present, eg, *Juncus* and *Cyperus*; and a groundstorey containing species typically found in North-west Slopes and New England grassy woodlands, such as *Dichondra repens, Chrysocephalum, Glycine, Wahlenburgia, Chielianthes, Austrostipa, Micloeana* and *Aristida* grass spp. In the spring, this community typically contains high numbers of greenhood *Pterostylis* and *Diuris* orchids, while in autumn providing habitat for the lily *Crinium flaccidum.*

The VIS database description of this community states the following typical community composition. Except for the presence of Native Olive *Notolea microcarpa,* there is a high level of correspondence with the species common at the survey sites:

544	Rough-barked Apple - White Cypress Pine - Blakely's Red Gum riparian open forest / woodland of the Nandewar Bioregion and New England Tableland Bioregion	Angophora floribunda, Eucalyptus blakelyi , Callitris glaucophylla , Eucalyptus melliodora / Notelaea microcarpa var. microcarpa , Leptospermum polygalifolium subsp. transmontanum / Lomandra longifolia , Dichondra sp. a , Microlaena stipoides var. stipoides , Cyperus gracilis

Considerable ground-truthing in the project area by Ethical Ecology has shown that PCT 399 is present, though generally found to be associated with lower order streams where the banks are less developed or absent. This describes the majority of steams in the Pilliga forests. Tea-tree and bottlebrush seems to grow as dominant parts of the understorey where there are relatively high levels of surface or shallow groundwater flow (hence its description as a 'wetland' in the VIS database). Intermittent spring and rain flow from the minor streams all feed into the Bohena alluvium.

As found in this study, some areas of the creekbed, particularly containing waterholes, conform to this community, though most of Bohena Creek has relatively little aquatic vegetation.

PCT ID401 covers over 7,500 ha and is called '*Rough-barked Apple - Blakely's Red Gum - Black Cypress Pine woodland on sandy flats, mainly in the Pilliga Scrub region*' in the VIS database. On the ground, Black Cypress Pine *Callitris endlicheri* was found to be not present in these claypan areas where this community occurs, but instead is occupied by White Cypress Pine. This appears to be an error within the PCT database itself as the original description of this community (in Benson *et al.* 2010) gives the associated *Callitris* as White Pine *C. glaucophylla.*

Correspondence with Box Gum Woodland

Appendix 2 also shows the levels of correspondence of the dominant woodland in this study with characteristic species listed under the NSW listing of the endangered ecological community *White Box Blakely's Red Gum Yellow Box Woodland.*

Of the 66 species identified in this study as being part of the riparian woodland community, 25 (42%) of these are listed as characteristic species under the Box Gum Woodland NSW Scientific Committee determination. Of the 94 characteristic species listed in the determination, 28 (28.7%) were found within the targeted riparian community. In both regards this measure of correspondence with the scientific determination is high, supporting the notion that the community described at PCT544 matches the listing of Box Gum Woodland under the *Threatened Species Conservation Act 1997*.

For the Commonwealth-listed Box Gum Woodland CEEC, key is the diversity of the forb component of the groundstorey;

"*A patch in which the perennial vegetation of the ground layer is dominated by native species, and which contains at least 12 native, non-grass understorey species (such as forbs, shrubs, ferns, grasses and sedges) is considered to have a sufficiently high level of native diversity to be the listed ecological community".*

Only eight of the 16 surveyed transects would meet this criterion, due to the variation in condition encountered at the transects. Overall it could be easily acknowledged that this community does correspond with the Commonwealth listing.

Tree dieback

Within the central area of Bohena Creek, between where Oil Well Road and Brandon's Road intersect Bohena Creek Road, patches of dieback seem to be affecting the riparian red gums. Some regrowth on the branches of these red gums is occurring now, no doubt in response to above average rainfall in 2016, but dead tree rates of 30% of all standing stems is high as was noticed at one site. Drone imagery of Bohena Creek above and below X-Line Road show significant areas of red gum dieback on both sides of the creek.

What is causing this dieback? A likely candidate is reduced surface flow due to drought throughout the 2000s as well as hot years in 2014 and 2015. But if this were the case why is there no evidence of significant dieback outside the affected zone?

Another potential impact on tree health would be depressed water tables. Red Gums are known to have relatively shallow root systems, and are prone to drops in water tables. But again, why only within one zone?

An inescapable correlation is the fact that the dieback zone lies within an area with a high number of active and historic gas wells. Given the environmental risk assessment provide in the EIS, impacts from gas activities could result in aquifer depressurisation as well as containation from coal seam water or other chemicals.

Further studies on water depth and quality in Bohena Creek warrants further investigation.

References

Benson JS, Richards PG, Waller S and Allen CB. 2010, 'New South Wales vegetation classification and assessment: Part 3 Plant communities of the NSW Brigalow Belt South, Nandewar and west New England Bioregions and update of NSW Western Plains and South-western Slopes plant communities, Version 3 of the NSWVCA database', *Cunninghamiana* 11(4), pp 457-579.

EcoLogical Australia, 2016. *Narrabri Gas Project: Ecological Impact Assessment.* Prepared for Santos NSW (Eastern) Pty Ltd.

Appendix 1: Data sheets for site surveys

Site No	**1**				
Description	Creaghs Crossing	Creaghs Road	Borah Creek		
t1		-30.77747	149.549219		
PCT	544				
Diversity	29				
Weed cover	15%				
Overstorey	Total	Angophora floribunda	Eucalyptus blakelyi	Callitris glaucophylla	
cover	30%				
height	15-20m				
Number >10cm	113 alive	64	9	40	
Dead trees	25 (18.1%)				
Midstorey	Total	Acacia polybotrya	Callitris glaucophylla	Acacia deanii	Acacia sertiformis
cover	10%				
Understorey	Total	Xanthorrhea acaulis	Hibbertia obtusifolia	Lomandra longifolia	Dianella revoluta
cover	20%				
Groundcover	Grasses 5	Forbs 12	litter	bare	
Cover	5%	5%	70-80%	5-10%	
Diversity	6	11			
t2		-30.77789	149.54866		
PCT	544				
Diversity	29				
Weed cover	30%				
Overstorey	Total	Angophora floribunda	Eucalyptus blakelyi	Callitris glaucophylla	Allocasuarina luehmannii
cover	20%				

height	15-20m				
Number >10cm	111	86	20	4	1
Dead trees	4 (3.5%)				
Midstorey	Total	Acacia deanii	Acacia polybotrya		
cover	10%				
Understorey	Total	Cyperus	Lomandra longifolia	Dianella revoluta	Lepidosperma laterale
cover	5%				
Groundcover	Grasses	Forbs	litter	bare	
Cover	<5%	<5%	90%	5%	
Diversity	6	10			
bed	-30.77755	149.54896			
Overstorey	Total				
cover	0				
Dead trees					
Midstorey	Total	Acacia deanii			
cover	<5%				
Understorey	Total				
cover	<5%				
Groundcover	Total				
Cover	<5%				

Site No	**2**			
Description	Garlands Crossing	Garlands Road	Bohena Creek	
t1		-30.70468	149.56732	
PCT	544			
Diversity	26			
Weed cover	10%			
Overstorey	Total	Angophora floribunda	Eucalyptus blakelyi	

cover	20-25%					
height	15-20m					
Stems >10cm	111	58	53			
Dead trees	12 (9.8%)					
Midstorey	Total	Acacia deanii	Callistemon linearis			
cover	10%					
Understorey	Total	Lomandra longifolia	Olearia elliptica	Gahnia aspera		
cover	35%					
Groundcover	Grasses	Forbs	litter	bare		
Cover	20%	30%	40%	10%		
Diversity	5	15				

t2		-30.70471	149.56652			
PCT	544					
Diversity	31					
Weed cover	10%					
Overstorey	Total	Angophora floribunda	Eucalyptus blakelyi	Callitris glaucophylla	Eucalyptus melliodora	Brachychiton populneus
cover	30%					
height	15-20m					
Number >10cm	83	16	28	37	1	1
Dead trees	10 (10.8%)					
Midstorey	Total	Acacia deanii	Callistemon linearis			
cover	5%					
Understorey	Total	Lomandra longifolia	Dianella longifolia	Gahnia aspera		
cover	10%					
Groundcover	Grasses	Forbs	litter	bare		
Cover (%)	20	40	30	<5		
Diversity	6	16				

bed	-30.70449	149.567004		
Overstorey	Total			
cover	0			
Midstorey	Total	Acacia deanii		
cover	5%			
Understorey	Total	Juncus	Cyperus	Gahnia aspera
cover	5%			
Groundcover	Total			
Cover	<5%			

Site No	**3**			
Description	Oil Well Rd crossing	Bohena Creek		
t1	-30.65929	149.59342		
PCT	544			
Diversity	20			
Weed cover	10%			
Overstorey	Total	Angophora floribunda	Eucalyptus blakelyi	Callitris glaucophylla
cover	10%			
height	15m			
Number >10cm	76	39	6	31
Dead trees	2 (2.6%)			
Midstorey	Total	Acacia deanii	Olearia elliptica	
cover	<5%			
Understorey	Total	Hibbertia obtusifolia	Melichrus urceolatus	
cover	10%			
Groundcover	Grasses	Forbs	litter	bare
Cover	<5%	<5%	85%	10%
Diversity	5	8		

t2	-30.65931	149.59219		
PCT	544			
Diversity	20			
Weed cover	30%			
Overstorey	Total	Angophora floribunda	Eucalyptus blakelyi	
cover	15%			
height	15-20m			
Number >10cm	69	27	42	
Dead trees	17 (19.8%)			
Midstorey	Total	Acacia deanii	Callistemon linearis	
cover	10%			
Understorey	Total	Lomandra longifolia	Gahnia aspera	
cover	<5%			
Groundcover	Grasses	Forbs	litter	bare
Cover	<5%	<5%	70%	25%
Diversity	6	9		

bed	-30.65926	149.59287	
Overstorey	Total		
cover	0		
Dead trees			
Midstorey	Total	Acacia deanii	
cover	<5%		
Understorey	Total	Juncus	Gahnia aspera
cover	<5%		
Groundstorey	Total		
cover	<5%		

Site No	4				
Description	Bohena Creek Road	Sth of Brandons Rd junction			
t1	-30.60316	149.63229			
PCT	401?				
Diversity	18				
Weed cover	35%				

Overstorey	Total	A. floribunda	C. glaucophylla	E. chloroclada	E. blakelyi
cover	20%				
height (m)	15				
Number >10cm	92	27	54	9	2
Dead trees	25 (21.4%)				

Midstorey	Total	A. deanii	C. glaucophylla
cover	25%		

Understorey	Total	Lomandra longifolia	Gahnia aspera
cover	10%		

Groundcover	Grasses	Forbs	litter	bare
Cover	5%	5	75	15
Diversity	5	6		

t2	-30.60343	149.63084
PCT	544	
Diversity	13	
Weed cover	40%	

Overstorey	Total	E. blakelyi	A. floribunda	C. glaucophylla
cover	5%			
height	20m			
Number >10cm	47	12	10	25
Dead trees	25 (34.7%)			

Midstorey cover	Total <5%	A. deanii		
Understorey cover	Total 10%	L. longifolia	Cyperus	
Groundcover Cover	Grasses <5% 4	Forbs <5% 3	litter 20%	bare 70%

bed	-30.60327	149.63158
Overstorey cover	Total	
Dead trees	0	
Midstorey cover	Total <5%	
Understorey cover	Total <5%	
Groundcover Cover	Total <5%	

Site No	**5**				
Description	Bohena Creek Road	Sth of Apple road junction			
t1	-30.56915	149.64954			
PCT	409				
Diversity	21				
Weed cover	5%				
Overstorey cover	Total 15%	Angophora floribunda	Callitris glaucophylla	Eucalyptus chloroclada	Eucalyptus blakelyi
height	15m				

Number >10cm	48	4	38	5		1
Dead trees	7 (12.7%)					
Midstorey	Total	Acacia deanii	Callitris glaucophylla			
cover	10%					
Understorey	Total	Melichrus urceolatus	Calytrix tetragona	Cryptandra amara	Leucopogon muricatus	
cover	30%					
Groundcover	Grasses	Forbs	litter	bare		
Cover	5%	5%	60%	30%		
Diversity	3	8				

t2	-30.56858	149.64850
PCT	544	

Diversity	21			
Weed cover	20%			
Overstorey	Total	Eucalyptus blakelyi	Callitris glaucophylla	
cover	10%			
height	15-20m			
Number >10cm	46	21	25	
Dead trees	8 (12.9%)			
Midstorey	Total	Acacia deanii		
cover	30%			
Understorey	Total	Lomandra longifolia	Gahnia aspera	
cover	30%			
Groundcover	Grasses	Forbs	litter	bare
Cover	5%	5%	80%	10%
Diversity	4	13		

bed	-30.55889	149.64905
Overstorey	Total	E. blakelyi
cover	<5%	
Dead trees		
Midstorey	Total	Acacia deanii
cover	5%	
Understorey	Total	Phragmites
cover	<5%	

Site No	6			
Description	Maudes Crossing	Maudes Road	Bohena Creek	
t1	-30.53889	149.65956		
PCT	544			
Diversity	23			
Weed cover	15%			
Overstorey	Total	E. blakelyi	A. floribunda	C. glaucophylla
cover	10%			
height	15m			
Number >10cm	108	8	1	96
Dead trees	20 (15.6%)			
Midstorey	Total	Acacia deanii		
cover	10%			
Understorey	Total	Lomandra longifolia	Gahnia aspera	
cover	5%			
Groundcover	Grasses	Forbs	litter	bare
Cover	10%	20%	40%	30%
Diversity	5	13		

t2	-30.53917	149.65875		
PCT	544			
Diversity	26			
Weed cover	10%			
Overstorey	Total	Angophora floribunda	E. blakelyi	C. glaucophylla
cover	20%			
height	15m			
Number >10cm	80	16	16	48
Dead trees	18 (18.4%)			
Midstorey	Total	A. deanii	C. glaucophylla	
cover	60%			
Understorey	Total	Lomandra longifolia	Crinium flaccidum	Gahnia aspera
cover	30%			
Groundcover	Grasses	Forbs	litter	bare
Cover	20%	20%	60%	0%
Diversity	5	14		
bed	-30.53900	149.65916		
Overstorey	Total			
cover	0			
Midstorey	Total			
cover	0			
Understorey	Total			
cover	<5%			
Groundcover	Total			
Cover	<5%			

Site No	**7**				
Description	Teds Hole	McCanns Road	Bohena Creek		
t1		-30.48398	149.65308		
PCT	544				
Diversity	29				
Weed cover	10%				
Overstorey	Total	Angophora floribunda	Eucalyptus blakelyi	Eucalyptus melliodora	Callitris glaucophylla
cover	15%				
height	15				
Number >10cm	78	19	12	2	45
Dead trees	12 (13.3%)				
Midstorey	Total	Acacia deanii	Callitris glaucophylla		
cover	5%				
Understorey	Total	Lomandra longifolia	Gahnia aspera		
cover	20%				
Groundcover	Grasses	Forbs	litter	bare	
Cover	20%	40%	35%	5%	
Diversity	6	16			
t2		-30.48431	149.65398		
PCT	544				
Diversity	21				
Weed cover	15%				
Overstorey	Total	Eucalyptus blakelyi	Angophora floribunda	Callitris glaucophylla	
cover	5%				

height	15			
Number >10cm	93	21	4	68
Dead trees	15 (13.9%)			
Midstorey	Total	Acacia deanii		
cover	5%			
Understorey	Total	Lomandra longifolia	Gahnia aspera	
cover	10%			
Groundcover	Grasses	Forbs	litter	bare
Cover	10%	10%	75%	5%
	4	11		
bed		-30.48418	149.65361	
Overstorey	Total	Eucalyptus blakelyi		
cover	5%			
Dead trees	0			
Midstorey	Total	Callistemon linearis	Leptospermum polygalifolium	Acacia deanii
cover	50%			
Understorey	Total	Juncus	Cyperus	Gahnia aspera
cover	10%			
Groundcover	Total			
Cover	<5%			

Site No	**8**			
Description	Newell Hwy Bridge	Bohena Creek		
t1		-30.44481	149.67121	
PCT	544			
Diversity	24			
Weed cover	5%			
Overstorey	Total	Angophora floribunda	Eucalyptus blakelyi	Callitris glaucophylla
cover	50%			
height	15m			
number <10cm	142	35	11	116
Dead trees	10 (6.6%)			
Midstorey	Total	Callistemon linearis	Acacia deanii	
cover	5%			
Understorey	Total	Lomandra longifolia	Brachyloma daphnoides	
cover	10%			
Groundcover	Grasses	Forbs	litter	bare
Cover	70%	20%	10%	0%
Diversity	5	12		
t2		-30.44577	149.67001	
PCT	544			
Diversity	24			
Weed cover	10%			
Overstorey	Total	Angophora floribunda	Eucalyptus blakelyi	Callitris glaucophylla
cover	25%			

Number <10cm	83	1	67	15	
Dead trees	5 (5.7%)				
Midstorey	Total	Leptospermum polygalifolium	Callitris glaucophylla		
cover	5%				
Understorey	Total	Lomandra longifolia	Gahnia aspera		
cover	5%				
Groundcover	Grasses	Forbs	litter	bare	
Cover	50%	20%	25%	5%	
Diversity	6	12			
bed		-30.44542	149.67049		
Overstorey	Total	Eucalyptus blakelyi			
cover	10%				
Dead trees	0				
Midstorey	Total	Callistemon linearis	Leptospermum polygalifolium	Acacia deanii	
cover	10%				
Understorey	Total	Juncus	Cyperus	Carex	Alternathera
cover	90%				
Groundcover	Total	Ariundella			
Cover	5%				

Appendix 2: Species list

Table 1. Species list of community PCT 544/401 showing diversity and correspondence with characteristic species listed under the NSW listing of the endangered ecological community *White Box Blakely's Red Gum Yellow Box Woodland.*

	Overstorey	7
x	Eucalyptus blakelyi	
	Eucalyptus chloroclada	
	Angophora floribunda	
x	Callitris glaucophylla	
x	Eucalyptus melliodora	
x	Brachychiton populneus	
	Allocasuarina leuhmannii	
	Midstorey	6
	Acacia deanii	
	Acacia polybotrya	
	Acacia sertiformis	
	Callistemon linearis	
	Leptospermum polygalifolium	
	Senna artemisoides	
	Understorey	14
	Lomandra longifolia	
x	Brachyloma daphnoides	
x	Dianella revoluta	
x	Dianella longifolia	
	Lepidosperma laterale	
	Crinium flaccidum	
	Persoonia sericea	
	Juncus sp	
	Cyperus sp	
x	Hibbertia obtusifolia	
	Xanthorrhea acaulis	
x	Melichrus urceolatus	
	Swainsona cadellii	
x	Olearia elliptica	
	Grasses	13
x	Aristida ramosa	
	Aristida caput-medusa	

	Aristida jerichoensis	
	Microleana stipiodes	
	Digitaria diffusum	
	Eragrostris brownii	
x	Cymbopogon refractus	
x	Austrostipa scabra	
	Austrostipa verticullata	
	Austrostipa setacea	
x	Themeda australis	
	Ariundella nepalensis	
x	Dichelachne micrantha	
	Forbs	26
	Dichondra repens	
	Helichrysum apiculatum	
x	Glycine clandestina	
x	Glycine tabacina	
x	Oxalis perennans	
	Pomax umbellata	
	Fimbristylus dichotoma	
	Urtica incisa	
x	Rumex brownii	
x	Sida corrugata	
	Gahnia aspera	
	Lomandra multiflora	
x	Brunoniella australis	
	Goodenia glabra	
	Goodenia hederacea	
x	Geranium solanderi	
x	Plantago debilis	
	Desmodium brachypodium	
x	Templetonia stenophylla	
	Poranthera microphylla	
x	Cheilanthes sieberi	
	Ajuga australis	
	Einadia trigonos	
	Podolepus jaceoides	
	Alternanthera denticulata	
	Commersonia procumbens	
25		66
41.7%		

Table 2. Characteristic species of the NSW listing of the endangered ecological community *White Box Blakely's Red Gum Yellow Box Woodland* and level of correspondence with species detected in this study.

Acacia buxifolia	
Acacia implexa	
Acacia paradoxa	
Allocasuarina verticillata	
Alectryon oleifolius	
Aristida behriana	
Aristida ramosa	x
Asperula conferta	
Atalaya hemiglauca	
Austrodanthonia auriculata	
Austrodanthonia bipartita	
Austrodanthonia racemosa	
Austrodanthonia richardsonii	
Austrostipa aristiglumis	
Austrostipa blackii	
Austrostipa nodosa	
Austrostipa scabra	x
Bothriochla macra	
Brachychiton populneus	x
Brachyloma daphnoides	x
Bracteantha viscosa	
Brunoniella australis	x
Bulbine bulbosa	
Bursaria spinosa	
Callitris endlicheri	
Callitris glaucophylla	x
Capparis mitchellii	
Cassinia longifolia	
Cassinia quinquefaria	
Cheilanthes sieberi	x
Chloris trucata	
Chloris ventricosa	
Chrysocephalum apiculatum	x
Cymbopogon refractus	x
Dianella longifolia	x
Dianella revoluta	x
Dichanthium sericeum	
Dichelachne micrantha	x
Dichelacne sciurea	

▯	Diuris dendrobioides	
▯	Dodonaea viscosa	
▯	Echinopogon caespitosus	
▯	Ehretia membranifolia	
▯	Elymus scaber	
▯	Eremophila mitchellii	
▯	Eucalyptus blakelyi	x
▯	Eucalyptus albens	
▯	Eucalyptus bridgesiana	
▯	Eucalyptus conica	
▯	Eucalyptus goniocalyx	
▯	Eucalyptus melliodora	x
▯	Eucalyptus microcarpa	
▯	Eucalyptus nortonii	
▯	Eulalia aurea	
▯	Exocarpos cupressiformis	
▯	Geijera parviflora	
▯	Geranium solanderi	x
▯	Glycine clandestina	x
▯	Glycine tabacina	x
▯	Glycine tomentella	
▯	Gonocarpus elatus	
▯	Goodenia pinnatifida	
▯	Hibbertia linearis	
▯	Hibbertia obtusifolia	x
▯	Hypericum gramineum	
▯	Jacksonia scoparia	
▯	Jasminum lineare	
▯	Jasminum suavissimum	
▯	Leptorhynchos squamatus	
▯	Lissanthe strigosa	
▯	Lomandra filiformis	
▯	Melichrus urceolatus	x
▯	Microseris lanceolata	
▯	Notelaea microcarpa	
▯	Olearia elliptica	x
▯	Olearia viscidula	
▯	Oxalis perennans	x
▯	Pandorea pandorana	
▯	Panicum queenslandicum	
▯	Parsonsia eucalyptophylla	
▯	Pimelea curviflora	
▯	Plantago debilis	x

□	Plantago gaudichaudii				
□	Poa labillardieri				
□	Poa sieberiana				
□	Rostellularia adscendens				
□	Rumex brownii		x		
□	Sida corrugata		x		
□	Sorghum leiocladum				
□	Stackhousia monogyna		x		
□	Stackhousia viminea				
□	Swainsona galegifolia				
□	Templetonia stenophylla		x		
□	Themeda australis		x		
□	Wahlenbergia sp		x		
		94		28	28.70%

Appendix 3: Drone shots of red gum dieback along Bohena Creek